SCIENCE IN THE FRANCIS W. PARKER SCHOOL.

WILLARD S. BASS,
FRANCIS W. PARKER SCHOOL, CHICAGO, ILL.

It will help us in our discussion if we distinguish two phases of science-teaching. Science is organized knowledge, and the two phases to be distinguished are (1) gaining the knowledge and (2) organizing it.

The presence of the latter phase as a conscious motive of teacher and pupil distinguishes the work of the secondary from that of the elementary school. The latter is "science," in the exact and restricted sense of the term; the former we will call "nature-study," including under that term a study of both animate and inanimate things.

It is the purpose of this paper to discuss the point of view, methods, and values of the science-teaching in our school, and to show the relations of nature-study to systematic science, and of both to mathematics.

"Nature study," says Hodge,[1] "is learning those things in nature which are best worth knowing, to the end of doing those things which make life most worth living." The end of the study is thus *action*—doing things. But what are the things the doing of which makes the pupil's life now and in the future most worth living, and what are the things which are therefore best worth knowing? "They are indicated in a fundamental way by the relations which the human race has found it necessary and valuable to develop with nature"—relations which have existed from prehistoric times, and which will persist through every advance of civilization.

These relations are mainly with *living* things—animals and plants. Upon plant and animal life primitive man depended entirely for his food, his clothing, and, excepting the cave-dweller, for his shelter. Our modern civilization has not altered this

[1] C. F. Hodge, *Nature Study and Life* (Boston: Ginn & Co.), p. 1. The writer wishes to acknowledge with gratitude the influence which Dr. Hodge's teaching and book have had upon his own views of nature-study.

fundamental dependence. We, too, go to plants and animals for our food and clothing, while the forest still furnishes most of our shelter. The chief difference between us and primitive man is the way in which these necessaries are secured. The primitive man who sought refuge from large animals by climbing trees and hiding in caves, who obtained his vegetables direct from nature's bounty, and his flesh by preying upon small animals, offers a profound contrast to the modern dweller in cities, to whom wild animals are unknown, whose food grows hundreds and even thousands of miles from his table, and whose clothing comes to his hand ready-to-wear.

Let us look for a moment at the steps by which man has advanced from his former simple and immediate relations with nature to his present complicated and remote ones. This progress has been due to a better control of the animate and inanimate forces of nature, and gaining this control has been and is the nature-study of the race.

The first step in this long series was the *subjugation of animals,* which victory left man no longer the prey of the cave bear and tiger, but their pursuer and hunter, and insured his continued existence. Even now, however, the conquest of animals is far from complete. Insects still destroy the crops of whole counties; vermin still annoy us; microbes still destroy thousands of lives.[2]

The next step was the *domestication of animals.* After man's existence was secure, he came to recognize that some animals could be made his friends and helpers instead of remaining enemies.

The first animal tamed was the dog, which is still the idol of the child's heart. Then came, also before the dawn of authentic history, domestication of the horse, sheep, goat, horned cattle, and most of our domestic birds; and it is self-evident that the family or tribe which first developed patience and intelligence to tame and utilize animal helpers must have rapidly outstripped all rivals in the race for life.

The next, and possibly a greater advance of the race, was the *cultivation of plants.*

[2] This and the two following paragraphs are condensed from Hodge. His chapter on "The Point of View" is a masterful argument for the predominance of the biological matter in nature-study.

This has constituted the largest factor in the transition of tribes from wandering nomads to stable, populous, civilized communities. In the stability of landhold we have the beginning of home as distinguished from the casual camping ground; and with the founding of homes came commerce and arts, literatures and sciences as well.

While man has been developing by the subjugation and domestication of animals, and the cultivation of plants, he has also been concerned with inanimate things. Ever since he began to earn his bread by the sweat of his brow, he has needed and used tools. In fact, we may say that his entire progress has been possible only by the aid of implements. A step in advance far greater than the invention of tools was made when man seized the forces of nature and compelled them to do his bidding. The harnessing of nature's inanimate forces is the last step in the nature-study of the race, and, in fact, reached its height only in the inventions of the nineteenth century.

There can be no doubt that in broad lines the development of the individual follows that of the race, and that the active doing things with nature which has been the chief means of advancing the race will prove most helpful to the child. To place the child in the conditions which have caused the race to advance, we must give him opportunity for action which seems of real value to him and worth his greatest effort. That these conditions are normal to the child and most favorable for his growth is shown by his own natural instincts and spontaneous activities — his love of pets, his desire for flowers, his joy at seeing plants grow, his eagerness to handle things and to make them go. These instincts are toward active relationship with things, and not toward passive contemplation. The child wants to play with his dog, and does not care at all whether Towser has three or five toes on a foot. He wants his garden to grow so that he may eat its products, and he cares little for the number of seed leaves on his beans and corn. A wide range of active first-hand contact with nature is the normal condition for the development of the child, as it has been the chief means in the progress of the race, "and to substitute for this contact the study of pictures, museum specimens, or caged animals is to miss the substance for the shadow."

We have tried to follow these principles in the selection of our work in nature-study. We have sought to make the work active, to have it of practical importance, and to bring the children into direct contact with nature. In the lower grades the attention is directed mainly to the study of living things and the use of tools, while in the upper grades the study of natural forces is gradually introduced.

The establishment of relations with animals begins in the kindergarten. The school cat and her kittens are wonderfully interesting to these little people. I am not certain that they know how many ears or how many tails she has, but pussy always received a joyous welcome from them. The upper grades, too, have a warm feeling for her, and anyone who watches the face of a sixth-grade child playing with the cat at recess will conclude that the animal has its function in a school. The first grade has had the care of a guinea pig for several months, and I never see a more happy or more eagerly busy crowd of children than when I watch these first-graders cleaning this animal's house in the morning and getting him ready for the day. Now, the care of him during the school day even does not suffice them, but the children must take turns in carrying him to their homes after school. The third grade has had an aquarium of turtles in the room through the year, and other aquaria have been in various rooms. Just now there is a great deal of interest in the development of a lot of tadpoles.

By far our greatest success with animals is with our bees. Our other animals are obliged to live in artificial surroundings and to lead lives more or less foreign to their natures. The bees, however, have a regulation hive, go out of doors to gather honey or pollen as they desire, build their combs and rear their young in their own fashion — all exactly as if their only function in life were to make honey for some hard-headed farmer. The only differences between their present life and what it would be if the farmer owned them are that they must travel some eight inches through a glass-topped tunnel to gain access to the open air, and that we can remove the wooden sides from their hive and look through glass at the walls of their city and the manifold activity

there. The hive is in the kindergarten room, and to the kindergarten children the bees are a never-ending source of wonder. The little people stand by the hour and watch the bees coming into the hive, and count those carrying pollen until they get to a hundred. Sometimes one child counts the bees with yellow pollen, while another takes those with red, and a third those with brown. The older grades also watch the hive with interest and have observed the laying of the eggs, the growth of the larva, the sealing up of the cells and distinguishing characteristics of worker and drone cells, the emergence of the young bee, and have made some study of the structure of the insect.

It is only a short step from getting acquainted with our domestic animals to the study of those which we meet in our garden and which affect our crops for good or ill. We have met thus far the earthworm, the groundbeetle, the cabbage worm, and the potato beetle. The latter two have not yet appeared this year, but probably they will not forget us. The young children always seem to think that earthworms eat the roots of plants, so when the kindergarten child first sees an earthworm he proceeds at once to cut him in two with his hoe. To convince the child of his mistaken opinion, it is only necessary to place a few earthworms in a jar of white sand, on the top of which is placed a little black earth, or, better still, leaves of various plants. A surprising increase in the quantity of black earth will occur within a few weeks; and if this experiment is accompanied by one to show the importance of black earth to plants, the child will not again deliberately cut earthworms in two. Experiments of this sort are now being carried on in the kindergarten, the second and fourth grades.

In the study of the cabbage worm and potato beetle the first point to be considered is how our crops can be protected from their ravages. In order to do this most effectively, we are led to the study of the life-history of the insect to learn from what place he makes his appearance and at what point we can attack him most successfully. While the study of the life-history is begun from this utilitarian motive, it is soon pursued for its own sake. The cabbage worm seems an unpromising field for anything

interesting, but when we watch its rapid growth, its formation of a cocoon, and its emergence as a white moth which immediately proceeds to lay more eggs, we have an example of the life-history of all insects — one of nature's deepest marvels.

Besides the insects, we have found this year in the garden two toads. These were captured, brought in, looked at, and their food was discussed. Then they were put into the garden and a board placed for them to live under, in the hope that they would stay there and devour insects. I am sorry to say that the inducements offered were not sufficient, and that they have apparently forsaken us.

Besides domestic animals and those found in the garden, the child is also interested in the wild life around him. The latter does not touch him so closely, but it appeals far more to his imagination and sense of the beautiful. Our aims in its study are to have the pupil realize in the life of the wild creature something akin to his own, and to find the part the creature plays in the economy of nature. For both these purposes we study the habits, food, and life-history of the animal. In knowing these facts we become acquainted and even friends with him. With this study a certain amount of naming and learning to recognize is essential. We try to do these things in ways which permit initiative on the part of the children and give as full play as possible to their powers. Cages have been made in which insects can be raised and their development watched. For preserving collections we have adopted a device[3] adapted especially for life-history collections. It consists of two plates of glass kept apart by a wooden rim; the specimens to be mounted are glued to one of the glasses,[4] and the whole is fastened together with passe-partout paper.

In attempting to reproduce in school those relations with plants which have aided the civilization of the race, we have had two places to work, the school grounds and the garden.

The object of the work on the grounds is to make the surroundings of the school as beautiful as possible. The raking and seeding of the lawn which have to be done every spring,

[3] See Hodge, p. 53.

[4] A little glycerin in LePage's glue will make it stick to the glass.

and the spading and manuring the soil around the hedges, have been done by the older pupils. Every spring we have had a formal planting. The work which any one pupil does on these occasions amounts to little, but in calling his attention to the desirability of having beautiful surroundings and in cultivating his æsthetic emotions we think it well worth while.

The garden is managed with an entirely different object—namely, to bring every child into close contact with the soil and have him learn the value of his own efforts in making things grow. We have tried to give to every child below the eighth grade some piece of ground which should be entirely his for this summer. He has chosen what he wanted to plant, has himself done the entire work of planting, will have the entire care of it during school, and will get all the products to dispose of as he likes. By this means he reaps the result of his own labors as directly and immediately as if he were making something in wood; only in this case his product depends not upon his own efforts alone, but also upon the closeness with which he makes them conform to the laws of nature.

Besides these individual beds, each grade has a large bed of some product upon which the class works together. The object of these class beds is, first, to furnish an illustration of the growth of the staple products of the country; second, to make experiments in their cultivation. The planting is generally preceded by some study of the best method to use. A careful record is made of what is done, and the results obtained in the fall are noted and recorded. Sometimes two ways of doing a thing are tried and their results compared. We hope that the records thus made will prove of value to future classes in showing the best procedure for our particular soil.

We use all or most of the products of these beds in our school work. Last year, for instance, the third grade grew tomatoes, and in the fall made them into pickles. The kindergarten grew popcorn, which was used at Christmas. The fifth grade grew flax, which they rotted and hackled and prepared for spinning. It had got too brittle, however, to be spun, probably because it was too old when cut. They have another bed of it this year.

The sixth grade grew sugar beets, and tried to extract and refine the sugar. Now, the extraction of sugar from sugar beets is a matter of some difficulty. Slicing the beets, soaking in water, and boiling down is easy enough, thus making a molasses, sweet but black and ill-smelling, and tasting disagreeably of the beet. For two years we have experimented in getting rid of these undesirable qualities. We have not succeeded yet, but our hopes were never higher. This year we have planted more sugar beets than ever before, and while we are not taking orders for sugar, we expect to obtain some which will be edible, if not marketable.

This year we are attempting to develop the economic importance of agricultural work, by keeping a careful record of the cost of the garden and the value of its products. The cost of manure, plowing, and other labor is divided among the different beds. Each grade keeps the record of the cost of the seeds, fertilizer, etc., used on its own beds. In the fall it will reckon the market value of the crop, and compute the profit or loss. In some grades this will be carried farther to find how much would have been made upon an acre of ground under the same conditions. The yield of our crops per acre will be computed and compared with the average yield in Illinois and other states. By this means we shall have an opportunity to compare our work and soil with that of the average farmer, and to see if we ought not to do better; and also it will enable us to realize how hard the farmer has to work for his product, and something of his importance to the community.

This spring we have started a new experiment by planting seeds of trees. We desire in this way to get the children acquainted with seeds and seedlings, to have them get over the feeling that there is something more mysterious about the appearance of trees than other plants, and to learn a lesson in patience. We hope that the patience will be rewarded, and that in four or five years we may see the blossoms on our own peach trees, and a little later on our pear, plum, cherry, and apple trees as well. The care of the trees, the budding, grafting, the digging of borers, and the keeping off of other insects, will furnish enough to do and enough to learn amply to justify the planting of the seeds.

I might at this point speak of some limitations of our school work in these lines. The children are absent in the summer—the time when the garden is at its height, when the labor is most exacting and the returns most abundant. The work is also limited by the smallness of the plots which can be assigned to each pupil. A four-foot square is the largest given any child. This is too small for him to really work on. As an object-lesson it is of the greatest value; but it is, after all, only an object-lesson, a model of a garden, an illustration of a farm; and models, object lessons, and illustrations can never take the place of the real things. The same is true even to a greater extent of our animals. A school cat and guinea pig are good things, but one cat for two hundred children does not give a sense of ownership nor a feeling of responsibility for its care; and one guinea pig can hardly establish with eighteen children those relations of mutual aid and dependence which have been the main channels by which the domestication of animals has contributed toward civilization.

The difficulty would not be helped much by a multiplication of cats or guinea pigs in school, and an increase in the size of the garden, while desirable, is impossible. We must look to other sources than the school for the establishment of these personal active relations with plants and animals which are of too much educational importance to the child to be omitted from his life. The country home is the natural and most effective place for the establishment of these relations; and though the city home offers much less chance for such work, yet there are few houses which do not possess some square feet of back yard that would look better for the planting of vines or flowers, or could be made to produce a few vegetables. It is a pity when any of these opportunities for the children are not utilized.

The great problem of a garden is, after all, how to make the plants grow, and a child working in a garden is sure in a little while to be seeking for things to help his plants. The main factors which influence the growth of plants are soil, moisture, temperature, and light. The finding out of the influence of these factors upon the plants, and the discovery of methods by which they can be controlled for the best growth of the plant, start

several lines of inquiry. Some of these open up topics of importance enough to be carried farther than the immediate needs of the garden demand. Some examples of this are given below.

The second grade performs experiments in growing things in different kinds of soil — sand, clay, loam, etc.; and the fourth grade carries the experiment farther and studies the effect of a particular kind of soil occurring over a large area.

The weather conditions of sunshine, rainfall, wind, and temperature are recorded in the lower grades. The effect of the weather upon the garden is, however, only one of the reasons for doing this work. The immediate effects of its changes upon the pupil and upon vegetation and animal life at large are other potent reasons. Several forms of weather records are kept in the lower grades, and a set of monthly landscapes is painted by some grades which shows strikingly the effect of seasonal changes. This work is extended in the fifth grade to a study of the climate of Chicago. In the sixth it is made the point of departure for a study of annual changes, especially of temperature, in which study the change in the sun's slant is shown to be the cause of summer and winter. In the seventh grade there is a study of climatic conditions all over the earth, in which the causes of climatic differences are discussed. This work is greatly helped by the fact that the pupils come to it with some idea of the meaning of statistics — such as thirty inches of rainfall in a year, and a mean monthly temperature of 20° or 65° — and are able to use the meaning of these figures in imaging the conditions of other places.

Finally, the direct effects of different heat, moisture, and light conditions upon the plant are observed. These observations and accompanying experiments are, of course, only of the most obvious kind at first, such as growing plants in windows where the light comes from one side, or growing them in the dark. Later comes the observation of characteristics of plants which naturally grow in different conditions — in swamps, prairie, ravine, sand dunes, etc. Lastly, the pupil tries to find out precisely the effect of water and light upon a plant, by a series of experiments in plant physiology in the seventh grade.

Cooking is a form of activity with natural products, we may

say of nature-study, which has existed from the dawn of history. It furnishes an admirable and logical supplement to the work in the garden, and it is also a point of departure for a great many experiments which are more purely scientific; *e. g.*, the effect of acids upon carbonates, the growth of yeast and its products, tests and characteristics of various fool principles, and the effect of heat upon them. These are not, however, the chief reasons for teaching cooking. The chief reason is that it answers our original requirement of nature-study; for is it not one of the things the doing of which makes life most worth living?

Many of you will agree with me that hand-work is the most efficient means which could be devised for enabling the children to gain control of the inanimate forces of nature. It is thus repeating the last step in the nature-study of the race, and its influence must be included in considering the science work of the school.

I wish to say a little about the relation of nature-study to mathematics. Out of the impressions and images of the external world are built all of our mental pictures and concepts. Words are of value only in so far as they awaken images in our mind of things we have already experienced. Mathematical symbols and expressions, unless they stand in the pupil's mind for some definite relationship in an external, concrete world, are meaningless and worse than useless. The material world is the place where these relationships exist, and getting control of natural forces and turning them to use is where the relationships become of importance to man. Work with these forces must, therefore, be the most natural and effective place for the study of these relationships which are the foundation of mathematics.

I have already mentioned in connection with the garden some things which could not be done without the use of arithmetic, and several more whose significance could not be understood without the use of number-processes, sometimes quite complicated. We are finding more and more of these problems each year, and a portion of the number-work of all grades consists of problems drawn from, or necessitated by, the work in science. It is the unanimous opinion of the teachers that these problems carry

home the reality of symbols and the meaning of processes as no amount of book-work can do, and that what is thus learned for the sake of immediate use is regarded of more worth and longer remembered than problems done with no motive but the gaining of facility in some process.

The above is not the case with concrete problems in which the pupil has no interest. In these he must understand the concrete thing or illustration first, and then the mathematical process. His difficulties are thereby increased, not diminished. This is especially so in many of the mercantile and commercial problems in text-books, where the thing talked about — promissory note, bill of exchange, stock, or bond — is entirely foreign to the life of the pupil. These things may have their place in the elementary school, but that place is after, not before, the arithmetical processes involved are well understood. The pupil's attention can then be directed to the conditions existing in the outside world which give rise to the paying of interest and commissions. The conditions understood, the principles underlying the transactions become plain and the mathematics almost obvious.

But these problems are too far from the life of the pupil to be used for the developing of his mathematics. The problem for the development of mathematical principles must be one whose solution is important and of immediate interest to the pupil, and one in which the concrete facts are easily seen, and in which the attention can therefore be directed to the mathematical principle involved. In the right working out of such problems comes the pupil's surest and most rapid mathematical progress. We have a good number of such problems already, and it is a cherished hope that we may finally obtain enough for the development of all needful mathematical principles, and for some, but probably not for all, of the drill necessary to give facility and accuracy.

We now turn to the second step in the acquisition of a science — the organization and systematization of the knowledge. The pupil should finish the elementary stage with the knowledge of many of the things of nature around him and considerable control over them. He has undoubtedly also grouped many of the facts together, and knows the relations of many of these groups

to himself. But up to this time he has not done much thinking about the relations of the facts and forces of nature to each other. We make the first extensive attempt to have the pupil do this in the eighth grade. The work of this grade, like that of preceding ones, is designed to secure an active contact with nature by observation, experiment, and work; and it seeks in addition to summarize and put into their proper relations the facts of science which the pupil has been learning through the seven previous grades, and to discover the relations which exist between those great organizations of knowledge known as the sciences of chemistry, physics, physiology, and botany. I shall in the following tell with some detail how this is done.

We began the work by calling the pupil's attention to the fact that most moving objects, such as street cars, locomotives, and automobiles, had a source of power or energy, which generally could be easily located. Animal bodies also move and do work, and the question was propounded as a basis for the year's work: "Must animal bodies, especially the human body, also be supplied with energy, if they are to do work? If this is so, from what source does the energy of the human body come?"

We first tried a set of experiments with pulleys, which showed that no combination of them could be made which would do more foot-pounds of work than was used up in running the pulleys. We generalized this to other machines, especially levers. We then began a study of the human body, and found that its work was done through a system of bony levers, and that the muscles applied the power to them. The muscles, therefore, must perform at least as many foot-pounds of work as are done by the hands and feet. A study of the structure of muscle showed the class that the power came from the contraction of a multitude of tiny striped fibers. Our question then became: "What source of energy gives these fibers the power of contraction?"

The class at once suggested food as the most probable source. So we tried a set of experiments on the composition of the common foods, and found that they all contained carbon. We knew that the burning of carbon outside the body produced heat, and that heat could be transformed into any desired form of energy

by the action of the steam engine, dynamo, etc. We, therefore, set to work to find what becomes of carbon when it is burned. After experiments extending over about four weeks, we came to the conclusion that carbon, in burning, unites with a gas called oxygen and forms a new substance, which is a heavy gas having the properties of putting out flame and turning lime water milky. This gas was found to exist to a slight extent in the atmosphere, and to a much greater extent in exhaled air.

Our problem was then to find how the food reaches the muscle. We first learned the different food-principles, and the test by which each can be recognized, the most important sources of each, the principles which should be observed in cooking each; and had some practice in the application of these principles. The digestion of each of these food-principles was studied; then their absorption and the various routes by which they get into the blood. In connection with this we studied the anatomy of the digestive system, and later of the circulatory and excretory systems. Most of this study was done from a papier maché mannikin, which represented solid models of the various organs. An effective method of work was to have the pupils make drawings of the organs being studied. The above work traced the route of the food from the mouth to the muscle.

We next studied respiration, and found that the lungs are constantly taking oxygen from the air and replacing it with carbon dioxide. We found that blood has the power of absorbing oxygen where that element is plentiful, and of giving it up where it is in demand. It then required small faith on the part of the pupils to believe that the blood carried oxygen to the muscle and brought back carbon dioxide. The matter was summed up as follows: The blood brings to the muscle sugar and proteid foods and oxygen. It carries away carbon dioxide and broken-down proteid.

The children at this point wrote papers answering, as well as they could, the question: "How does the muscle get its energy?" These papers required the hardest thinking done in the course. The pupils very generally arrived at the conclusion that the energy came from the union in the muscle of carbon and oxygen; that the

carbon came from the sugar and proteid in the blood; that the oxygen was brought from the lungs by the red blood corpuscles; and that the union formed carbon dioxide, which was carried away by the blood and eliminated by the lungs.

The class then raised the question: " If animals are constantly producing carbon dioxide, why does not all the oxygen of the air become replaced by carbon dioxide." They suspect that plants have something to do with it, and we shall spend the rest of the year in showing how plants are able, by the action of sunlight upon their green leaves, to change carbon dioxide and water into starch and oxygen, the one of which becomes food for man and the other his breath.

This great cycle of carbon from the inorganic, inert carbon dioxide, up through the plant where it is elaborated into starches and sugars, into the animal where, after becoming a part of still more complex tissues, it is finally reduced again into carbon dioxide, is to me the most impressive illustration of the conservation of matter. The marvel deepens when we think that this carbon, separated from its oxygen and seeking it again, carries the energy for all human endeavor, and that, when once used, it can be made available again only by the action of energy from that far-away source, the sun.

This course serves as an introduction to our high-school science. From it, as a starting-place, we can continue the study of energy and its various changes, which is the science of physics; or investigate the transformations of matter, which is chemistry; or we can study systematically the structure and behavior of animals, which is zoölogy; or that of plants, which is botany. In any case, we ought to know how the particular group of facts studied is related to the other groups, and that nature and science are not manifold, but one.

We have chosen physics for our second year's work in science. Our work here is along more conventional lines than that of the first year. Of course, we use the laboratory method, and stand by our original principles of having the pupil get into as active relations as possible with the thing studied; and we select for that purpose those topics which seem of practical value in life. But in all these respects we can make no claim to uniqueness.

There are two respects in which we do differ somewhat from the ordinary school: (1) Our pupils begin, and still more in the future they will begin, this course with considerable knowledge of the facts of physics. For instance, the third grade studies the water supply of Chicago; the fifth, the boiling of water and the heating apparatus of the building; the sixth, air-pressure and the barometer. This gives the pupil a much broader and better base for his generalization than when he must make his generalizations and learn his facts at the same time. (2) An unusual amount of apparatus has been constructed by the pupils. It needs no argument to show the better understanding and control of the apparatus, which this gives them.

The relation of mathematics to this work in physical science is a most interesting problem, but it is too large to be treated in this paper. Suffice it to say that the relationship has long been recognized by teachers of physics, and is beginning to be by teachers of mathematics; but little use has thus far been made of it in teaching. It has been found during the year that the physics has shed much light upon some parts of algebra; *e. g.*, meaning of negative numbers and their addition and subtraction, proportion and variation, the equation as a law, square root. During the next year a consistent attempt will be made to develop the algebra of the tenth grade from suitably selected experiments in physics.

And when, at last, the pupil has finished his school work in nature-study and science, what will he have gained from them?

First, from a utilitarian standpoint he will be familiar with a good many industrial processes and be able to do amateur work in several. He will have understanding and control of those forces of nature with which everyone comes into contact in his daily life — those involved in cooking, housekeeping, gardening, the care of animals, etc.; and will have the knowledge and manual dexterity to use them to his own ends. In a broader sense, he will know the mutual relations and interdependence of many industries — a thing of value in whatever vocation he may adopt.

Intellectually, he has been thinking in scientific things and by the scientific method. The scientific method of thinking may be

summarized as follows: gathering data by observation, making a hypothetical law or generalization from these data, deducing consequences from this law, and testing the consequences by experiment. If the results of the experiment tally with the hypothesis, the latter may be stated as a law. Now, Dr. Dewey says that this method of thought demanded by the science is the only possible way of true thinking.[5] The study of science ought, therefore, pre-eminently to develop the power of clear and logical thinking. This is a deduction which, I believe, is verified by a study of the facts.

Nature-study also aids intellectual development by establishing new interests. The fulness of one's mental life is largely dependent upon the number of things in which he is, or may be, interested. To one familiar with her, Nature offers a wonderful variety of such interests. She is by turns amazing and quieting, thrilling and peaceful, beautiful and terrible. To her we may go for inspiration or solace, for work or for rest. To be her friend is to have a certainty of perennial interests.

Ethically, science studied as we have indicated helps accomplish one great result: it substitutes an active for a repressive method in dealing with moral questions. It teaches boys to study birds and build places for their nests, instead of molesting them and making game wardens necessary for their protection. It teaches boys how to grow grapes and peaches of their own, and does not make laws to prevent their stealing from others.

Finally, we may also claim for science a distinctly religious value. For do not the order, regularity, and precision with which effect follows cause in nature's domain indicate a single underlying and unifying law? And what is religion but to work in accordance with this law for the creation of happiness and the good of men? The child who cares for an animal, raises a plant, or makes some article for the comfort or well-being of men is working hand in hand with nature. And what truer religion can there be than that he thus become the image of his Creator?

[5] John Dewey, address before the Central Association of Science and Mathematics Teachers, November, 1903.